This document contains Part 2 (pp.172–179) of Chapter 6 of the National Coastal Condition Report III.

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National Coastal Condition Report III

Chapter 6: West Coast Coastal Condition

Part 2 of 3

December 2008

Trends of Coastal Monitoring Data—West Coast Region

Temporal Change in Ecological Condition

As a pilot project, the NCA survey of the West Coast region was initially designed to develop trends in condition. The region was reassessed in 2004–2006 to determine trends, but these data were unavailable for inclusion in this report; therefore, a regional assessment of trends for West Coast coastal condition is not possible at this time.

Three local monitoring programs have sampled significant percentages of the coastal area of the West Coast region for periods up to nearly 35 years, and these programs measure many of the same parameters (e.g., sediment contaminants) as the NCA. The Puget Sound Ambient Monitoring Program (PSAMP) conducted annual assessments of sediment contamination, sediment properties, and benthic community composition at 10 fixed sites from 1989 through 2000. The principal agency conducting the sediment assessment is the WDOE, which was also the lead agency for the 1999–2000 NCA survey in Washington. Within San Francisco Bay, the Regional Monitoring Program for Trace Substances (RMP) has monitored chemical contaminant levels in water, sediments, and biota since 1993. The longest-running monitoring study in the region has been conducted primarily by the Los Angeles County Sanitation Districts (LACSD) to assess the condition of sediment and benthic and fish communities, as well as the levels of chemical contaminants in fish, for a series of sites on the Palos Verdes Shelf within the SCB. Although these long-term monitoring data have been collected from fixed stations, probability-based assessments within the SCB have also been conducted.

Changes and Trends in Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program, 1989–2000

As part of the PSAMP, the WDOE sampled sediments at 10 fixed sites that were chosen from a variety of habitats and geographic locations in Puget Sound (Figure 6-8). Sediments from each site were analyzed for particle size, organic carbon content, and sediment contaminant concentrations, as well as for the types and abundances of benthic organisms present. Samples were collected each spring between 1989 and 2000; however, samples collected between 1997 and 1999 were not analyzed for sediment contaminant concentrations. Changes in sediment condition over the 1989–2000 time period provide evidence for both human-driven and naturally occurring influences on the marine ecosystem (Partridge et al., 2005).

Figure 6-8. Locations of the 10 long-term PSAMP sediment monitoring stations in Puget Sound (courtesy of WDOE).

Human-Driven Changes

The PSAMP analyzed sediment samples for more than 120 contaminants, such as metals (i.e., priority pollutant and ancillary) and organic compounds (e.g., PAHs, chlorinated pesticides, PCBs). The most notable changes in sediment chemistry were in metal and PAH concentrations.

The concentrations of most metals did not change significantly over the study period; however, those that did change generally decreased. Significant decreases were observed in copper levels across all stations and in metal concentrations, in general, at stations in Port Gardner and Budd Inlet (Partridge et al., 2005). Freshwater and estuary sediment metal concentrations have exhibited similar declines nationwide since the mid-1970s. These trends may reflect decreases in emissions to air and water from municipal and industrial sources following the implementation of federal clean water and air regulations; however, despite these improvements, metal concentrations remain above sediment quality guidelines in many urban bays of Puget Sound, emphasizing the need for continued monitoring and cleanup (Lefkovitz et al., 1997; Mahler et al., 2004).

Port Townsend, WA (courtesy of Gary Wilson, NRCS).

The concentrations of most PAH compounds in sediment did not change significantly during the PSAMP study period; however, most of those that did change increased in concentration. Significant increases in benzofluoranthene levels were observed throughout the study area, and increases in PAH concentrations were observed at sites in Bellingham Bay, Port Gardner, and Anderson Island. In contrast, there was a significant decrease in PAH concentrations at the Point Pully site (Partridge et al., 2005). These results are consistent with nationwide trends. After peaking between the mid-1940s and the 1960s, nationwide PAH levels in sediment core samples decreased through the 1980s and have more recently increased. It is believed that the early declines in PAH concentrations can be attributed to the switch from coal to oil and natural gas for home heating, improvements in industrial emissions controls, and increases in the efficiency of power plants, whereas more recent increases have been linked to increasing urban sprawl and vehicle traffic in urban and suburban areas (Lefkovitz et al., 1997; Van Metre et al., 2000; Van Metre and Mahler, 2005). Recent studies by the USGS have also measured high PAH concentrations in stormwater runoff from parking lots sealed with coal-tar-based asphalt sealants (Mahler et al., 2005).

Naturally Occurring Changes

From 1989 through 1995, the amount of fine-grained sediment (percent silt) at the Strait of Georgia site varied between 25% and 50%. Between 1995 and 1997, the percent silt in the sediment rose to approximately 90%, then declined to about 50% between 1998 and 2000. During the PSAMP study, the benthic community in the Strait of Georgia changed from one characterized by multiple annelid worm species (i.e., *Prionospio*, *Pholoe*, and *Cossura*) to one consisting primarily of *Cossura*, a mobile burrower that tolerates living in a wide range of sediment grain sizes, and finally to one dominated by the bivalve mollusks *Macoma* and *Yoldia*, which are also active burrowers (Figure 6-9) (Partridge et al., 2005).

Examination of the flow and discharge plume of British Columbia's Fraser River, which can carry heavy sediment loads into the Strait of Georgia, suggested a possible cause for the observed changes.

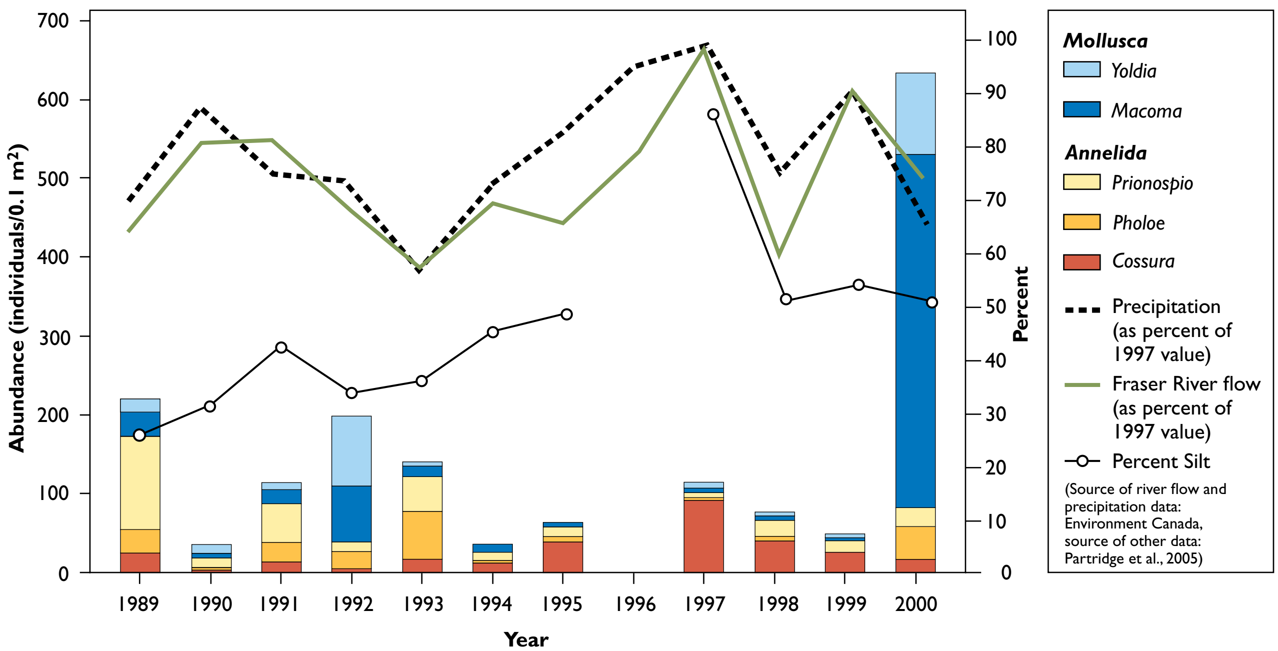

Figure 6-9. Changes in percent silt and abundance of dominant annelids and mollusks at the Strait of Georgia station, along with patterns in Fraser River flow and precipitation at the Vancouver International Airport. River flow and precipitation displayed as percent of highest value (courtesy of WDOE).

Annual rainfall, Fraser River flow volumes, and the percent silt at the Strait of Georgia site all exhibit similar temporal patterns. It is hypothesized that the changes in the sediment community observed in the Strait of Georgia were driven by above-average precipitation in 1996–1997, which increased the flow in the Fraser River and resulted in increased deposition of fine sediments in northern Puget Sound. Changes in grain size are known to influence community structure (Partridge et al., 2005).

Changes in the Strait of Georgia's sediment community in response to naturally occurring variations in rainfall and river flow clearly show the value of long-term monitoring for understanding the effects of stressors on the Puget Sound ecosystem. Understanding these processes at a local scale can help with assessments of similar changes in other regions. For example, the sediment-community changes observed in the Strait of Georgia may hold the key to understanding recent declines in San Juan Island eelgrass populations.

Acting on the results of the PSAMP sediment monitoring program, investigators from the University of Washington and the USGS are conducting sediment surveys to determine if the decline in eelgrass abundance can also be linked to the deposition of fine-grained sediments from the Fraser River (Partridge et al., 2005).

The PSAMP's long-term monitoring provides a vital record of sediment conditions in Puget Sound and gives insight into the effects of both natural and human-driven stressors on the estuary. The fixed "sentinel" stations monitored in this program can raise red flags, highlighting important environmental changes that affect Puget Sound. These results are critical for guiding the policy and regulatory decisions needed to effectively manage and maintain the environmental health of Puget Sound. General information and data generated from this survey can be accessed from WDOE's Marine Sediment Monitoring Web site: http://www.ecy.wa.gov/programs/eap/mar_sed/msm_intr.html.

Trends in Environmental Condition in San Francisco Bay

San Francisco Bay (Figure 6-10) has had the benefit of several long-term monitoring programs, including the RMP, sampling and analysis by the USGS, and the Interagency Ecological Program (IEP). The RMP has investigated chemical contamination in the water, sediments, and biota of the Bay since 1993 and provides data on spatial patterns and long-term trends for use in management of the estuary (SFEI, 2003). The USGS has 35 years of water quality data, including data on parameters such as chlorophyll, nutrients (phosphorus and nitrogen), suspended sediments, and dissolved oxygen. These data provide a record of biological and chemical changes in the Bay, such as improvements in dissolved oxygen concentrations in the South Bay and changes in phytoplankton production in Suisun Bay (USGS, 2006b). The IEP has monitored fisheries and the effects of freshwater diversions on the biota of the Bay and the Sacramento-San Joaquin Delta since 1971 (IEP, 2006). Recent IEP data have shown drastic declines in important Delta fish species, such as striped bass, delta smelt, and longfin smelt (Hieb et al., 2005). Other local, state, and national programs, such as the Bay Protection and Toxic Cleanup Program, state Mussel Watch Program, Coastal Intensive Sites Network (CISNet), EMAP, and NOAA's NS&T Program, have also provided data on the water, sediments, and biota of San Francisco Bay.

Current and historical activities have contributed PCBs, pesticides, and mercury and other heavy metals (e.g., silver, copper) to the sediments of San Francisco Bay. Although many of these contaminants have been banned, they are persistent in the environment, biomagnify through the food web, and bioaccumulate in fish and wildlife. The highest concentrations of sediment contaminants are most often found at the urbanized edges of the Bay, and the distribution of contaminants is primarily driven by two factors: inputs from industrial and military sources near San Jose and the South San Francisco, Oakland, and East Bay shorelines and the distribution of fine particles to which these contaminants are sorbed. Many of the areas with high concentrations of PCBs, DDT, and/or chlordane in sediment correspond to areas of the estuary (i.e., South San Francisco Bay, San Pablo Bay, and along the East Bay shorelines) with high percentages of fine sediments (Connor et al., 2004).

Figure 6-10. Map of San Francisco Bay (courtesy of San Francisco Estuary Institute).

Mercury contamination in San Francisco Bay dates back to 19th-century mining practices, and sediment cores from the South Bay reflect historic changes in concentrations over time (SFEI, 2004). Pre-mining concentrations were about four to five times lower than today's concentrations (Conaway et al., 2003). A peak in mercury concentrations occurred during the early to mid-20th century, coinciding with the height of mining activities at the New Almaden Mercury Mine. This mine was the richest mercury mine in the state and is located on the Guadalupe River, which drains into the South Bay.

Contaminant levels in fish and wildlife have been the main concerns of the TMDLs being developed by the San Francisco Bay Regional Water Quality Board. For example, 25 years after the ban on the use of PCBs in California, concentrations in some Bay sport fish remain 10 times higher than

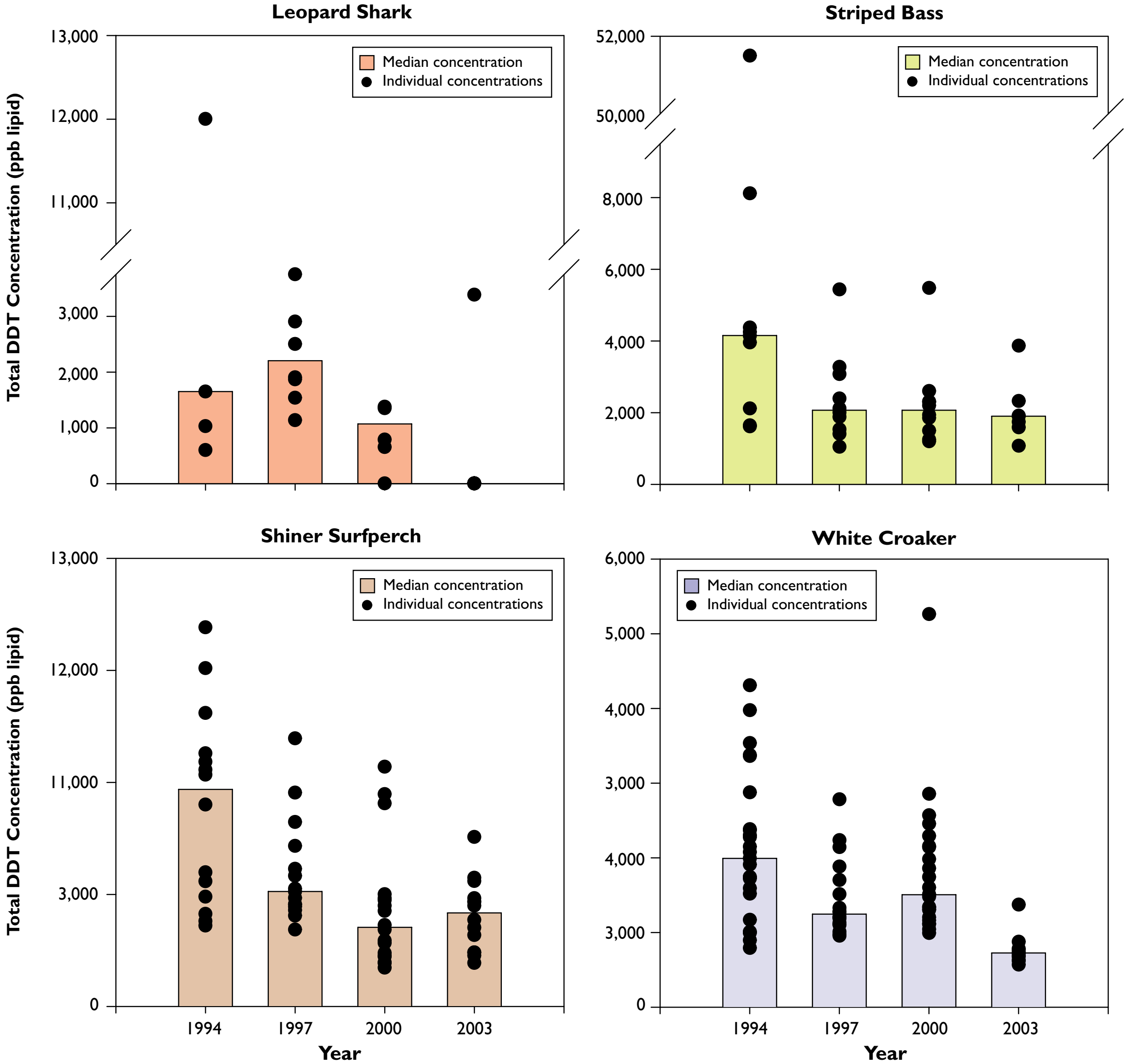

Figure 6-11. Total DDT concentrations in leopard shark, shiner surfperch, striped bass, and white croaker in ppb lipid weight, 1994–2003 (courtesy of San Francisco Estuary Institute).

human health consumption guidelines (Davis et al., 2006). Fish contaminants data have also been analyzed to determine whether there have been long-term changes in contaminant levels. Over the long term, concentrations of lipid-normalized DDTs in leopard shark, shiner, and white croaker suggest statistically significant declines in concentrations from 1994 to 2003 (Figure 6-11) (Connor et al., 2004). No long-term trends have been detected in lipid-normalized PCB data. PCB levels in leopard shark, white croaker, and striped bass were higher in 1994 compared to other years, but interannual variation since 1994 has fluctuated without a clear decline. Mercury concentrations in striped bass have shown no decline during the period from 1970–2003 (Figure 6-12) (Greenfield et al., 2005).

Declining concentrations of PCBs in transplanted mussels have suggested that water quality has improved in the Bay. Linear regression analyses have shown exponential declines in PCB concentrations in mussels at most transplant locations from 1980 to 2003. Similar declines in concentrations of legacy pesticides have also been seen in Bay transplanted mussels (Davis et al., 2006).

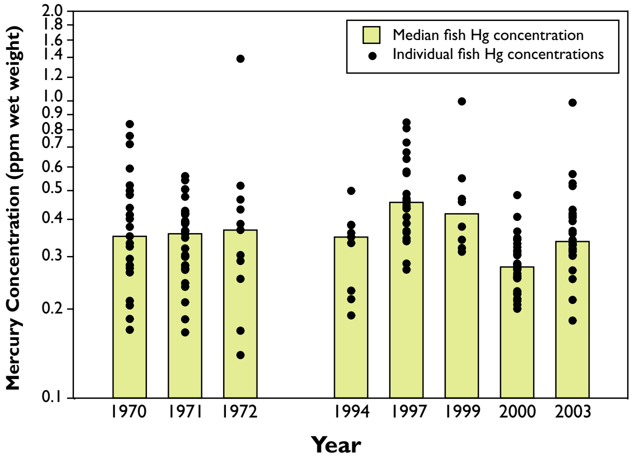

Figure 6-12. Mercury concentrations in ppm wet weight in striped bass from 1970–2003. Concentrations expressed as an average for a 55 cm fish (courtesy of San Francisco Estuary Institute).

Other contaminants have shown more declines. Copper concentrations in water, clams, and sediments from the South Bay declined from 1979 to 2003. RMP water data show statistically significant declines in copper concentrations at all historical South Bay stations, and USGS data show corresponding declines in copper concentrations measured in the clam *Macoma balthica* and in sediments from the South Bay. Declines of copper in *Macoma* have been correlated with declines in copper in effluents from the Palo Alto wastewater treatment plant (WWTP) located in the South Bay (SFEI, 2004).

Primary production in San Francisco Bay has historically been light-limited because of this waterbody's turbidity (SEFI, 2004). In recent years, chlorophyll levels in the southern reaches of the Bay have increased (Figure 6-13), which may be due to increased light penetration (SFEI, 2006). A South Bay suspended-sediment model, developed by USGS, predicts that increases in wetland area (as proposed under the South Bay Salt Pond Project) could result in increased sediment deposition onto wetlands and a subsequent decrease in suspended sediments in the water column (Shellenbarger et al., 2004). The resulting increase in light penetration could cause higher phytoplankton productivity. In the northern reaches of the estuary, chlorophyll concentrations have dramatically decreased in Suisun Bay sites (Figure 6-14) since the invasion of the freshwater clam *Corbula amurensis* in 1986. The high abundance of this filter-feeding clam has resulted in declines in chlorophyll in Suisun Bay, from an average of 9.8 mg/L (pre-invasion) to 2.1 mg/L (post-invasion) (SFEI, 2003).

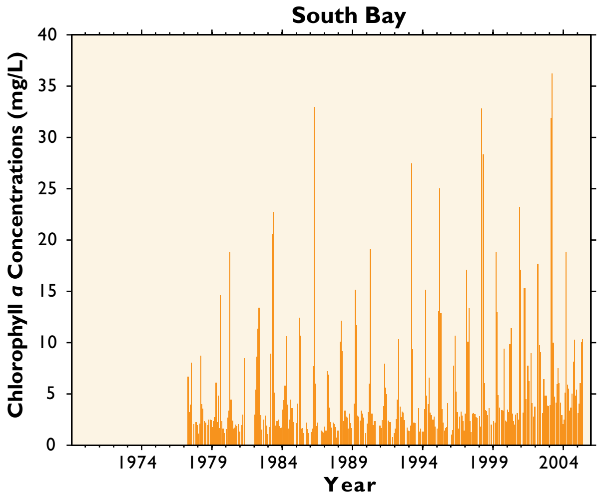

Figure 6-13. Chlorophyll *a* concentrations (mg/L) in South Bay, 1977–2004 (based on USGS data, courtesy of San Francisco Estuary Institute).

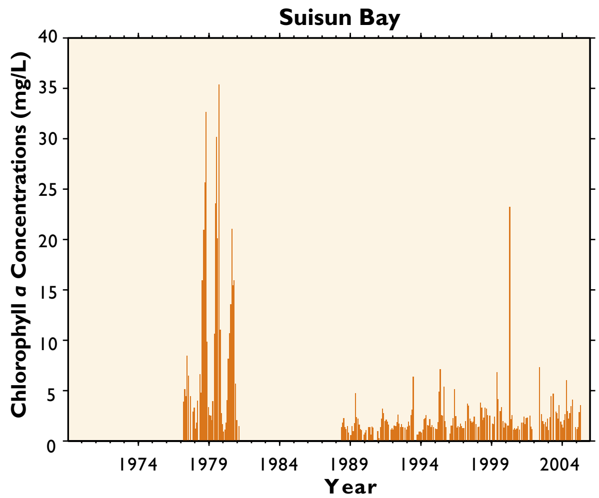

Figure 6-14. Chlorophyll *a* concentrations (mg/L) in Suisun Bay, 1977–2004 (based on USGS data, courtesy of San Francisco Estuary Institute).

Highlight

Development of Sediment Quality Objectives in California

An often overlooked benefit of the partnership between the EPA NCA and the states is the development of assessment tools. The California State Water Resources Control Board is required by the State of California's Porter-Cologne Water Quality Control Act (California Water Code, Division 7. Water Quality, Section 13393) to develop sediment quality objectives (SQOs) as part of a comprehensive program to protect existing and future beneficial uses within California's enclosed bays and estuaries. The process of developing SQOs has proven to be difficult both for EPA on a national basis and for many states on an individual basis. California is making progress toward developing direct-effects SQOs, in large part because of the data generated through probability-based, regional monitoring efforts supported by EMAP, the EMAP Western Pilot Project, and NCA beginning in 1999 (SWRCB, 2006).

Direct-effects SQOs are established to protect those organisms that are directly exposed to pollutants in sediments and to determine if sediment quality is negatively impacting those organisms. Reference condition is used to determine protected or optimal conditions. The State of California has proposed using a multiple-lines-of-evidence approach to SQOs, based upon a measure of exposure and two measures of biological condition. The three indicators that are being proposed are sediment contaminant concentrations, sediment toxicity, and benthic community condition. These indicators were selected to provide greater confidence in the decision-making process because benthic invertebrates are the focus of direct-effects SQOs. NCA data from bays and estuaries on the West Coast have provided an unbiased, synoptic data set to test various approaches. These data have been merged with other high-quality, site-specific data sets, such as the data for San Francisco Bay from the RMP. Approximately half of the data are being used to evaluate the utility of various measures of exposure, toxicity, and benthic community structure to assess sediment condition. The other half of the data set will be used to validate the approach for statewide application (SWRCB, 2006).

A summary of the process for developing and ultimately for implementing these SQOs can be found on California Environmental Protection Agency State Water Resources Control Board's Web site: http://www.swrcb.ca.gov/bptcp/sediment.html. For more information, contact Chris Beegan at (916) 341-5577.

Courtesy of Brad Ashbaugh

Direct-Effects Sediment Quality Objectives

Because the benthic invertebrates are the focus of direct-effects SQOs, sediment contaminant concentrations, sediment toxicity, and benthic comminity condition will be applied to provide greater confidence in the decision-making process. The steps involved in setting and implementing SQOs are described below.

1. **Set a Direct Effects SQO:** An example of a direct-effects narrative objective is "Sediment quality shall be maintained at a level that protects benthic invertebrates from degradation caused by bio-available pollutants in sediments."
2. **Implement the Narrative Direct-Effects SQO:** A narrative objective must be linked to a methodology that describes how the narrative objective is implemented. Multiple thresholds will be developed for each indicator and used to assess a response at a particular station (see table).
3. **Assess Each Station Using Three Lines of Evidence and the Tool-Specific Thresholds:** Finally, a method to integrate the three results will be developed to describe sediment quality at the station level.

Sediment Toxicity		Sediment Contaminant Concentrations		Benthic Community Condition	
Response	Threshold	Response	Threshold	Response	Threshold
	T^0 tox		T^0 chem		T^0 ben
	T^1 tox	x	T^1 chem		T^1 ben
x	T^2 tox		T^2 chem		T^2 ben
	T^3 tox		T^3 chem	x	T^3 ben
	T^4 tox		T^4 chem		T^4 ben

Notes: The implementation tools cannot be used to identify the cause of impairment. This is the fundamental limitation with these current tools. Before any mitigation or restoration can begin, the stressor must be identified.
Although bulk chemistry data can quantify which pollutants are present, these data do not provide any information on bio-availibility. Many pollutants are bound by organics or anions in the sediment that prevent the pollutant from causing toxicity.
The implementation of the narrative SQO is based solely on the application of multiple lines of evidence. No single line of evidence should be used in any application because of the limitations associated with the tool used to quantify the condition or response of the indicator or the limitations associated with the indicator itself.